2009 High Performance Computing Modernization Program Users Group Conference

US DoD S&T Priorities
17June 2009

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The Next Phases of Development
--Thoughts from the Secretary of Defense--

"*I believe the Department should seek increasing competition, use of prototypes, and ensure technology maturity so that our programs are ready for the next phases of development…*"

Secretary Gates before the SASC,
January 27, 2009

The strategy (National Defense Strategy) strives for balance in three areas: between trying to prevail in current conflicts and preparing for other contingencies, between institutionalizing capabilities such as counterinsurgency and foreign military assistance and maintaining the United States' existing conventional and strategic technological edge against other military forces, and between retaining those cultural traits that have made the U.S. armed forces successful and shedding those that hamper their ability to do what needs to be done.

Foreign Affairs Magazine Jan / Feb 2009

DDR&E VISION: To develop technology to defeat any adversary on any battlefield

Any Battlefield includes physical, cyber, space, undersea, etc

Any adversary includes both State & non-State actors

Transformation

Forces of Change…

Changing International Factors → **Defense S&T for Persistent Conflict** ← **Changing Warfare Factors**

NEW TECHNOLOGY NEEDED
What does this mean for the Department…?

Our New World . . .

- Black Swan Syndrome
- Information Agility
- Pace of Technology
- Economic Mega Trends
- Rise of The Commons
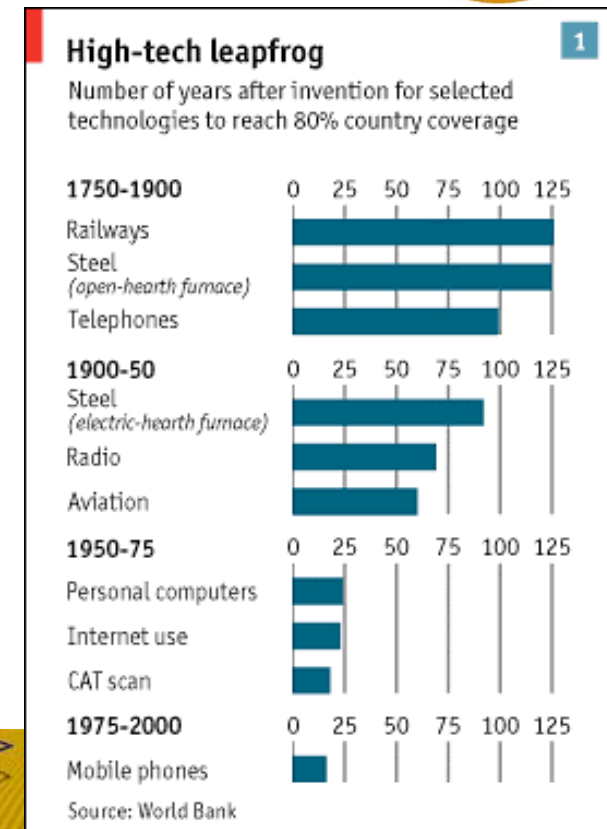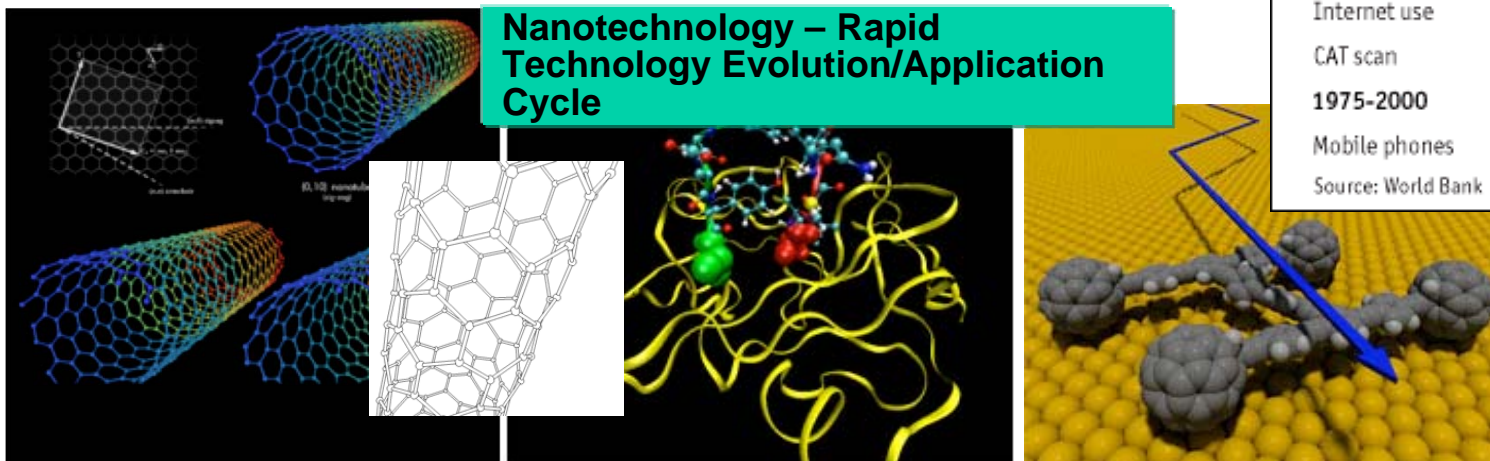- Technology Commercial-ization
- Expanding Global Knowledge Base

When the rate of change outside your organization exceeds that within your organization, the end is near. - *Jack Welch, former CEO, General Electric*

Pace of Technology Continues to Increase

- Time between modeling of semiconducting properties of germanium in 1931 and first commercial product *(transistor radio)* was 23 years

- Carbon nanotube
  - Discovered by Japan (1991)
  - Researchers recognized carbon nanotubes were excellent sources of field-emitted electrons (1995)
  - "Jumbotron lamp" - nanotube-based light source available as commercial product (2000)

Nanotechnology – Rapid Technology Evolution/Application Cycle

High-tech leapfrog

Number of years after invention for selected technologies to reach 80% country coverage

1750-1900	0	25	50	75	100	125
Railways						
Steel (open-hearth furnace)						
Telephones						

1900-50	0	25	50	75	100	125
Steel (electric-hearth furnace)						
Radio						
Aviation						

1950-75	0	25	50	75	100	125
Personal computers						
Internet use						
CAT scan						

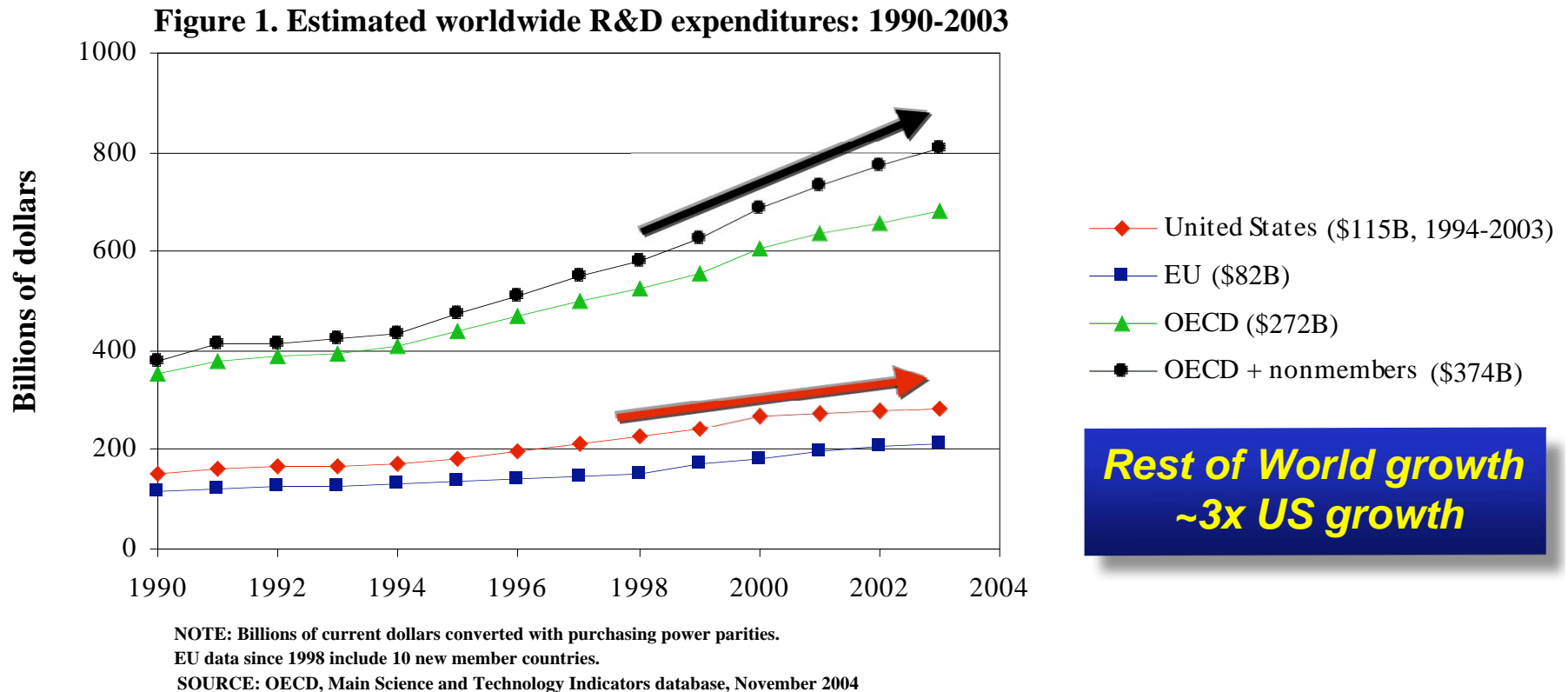| 1975-2000	0	25	50	75	100	125
Mobile phones						

Source: World Bank

Source: The Economist, Feb. 9, 2008

International R&D Trends

R&D expenditures are increasing robustly around the world, driven by both governments and industry.
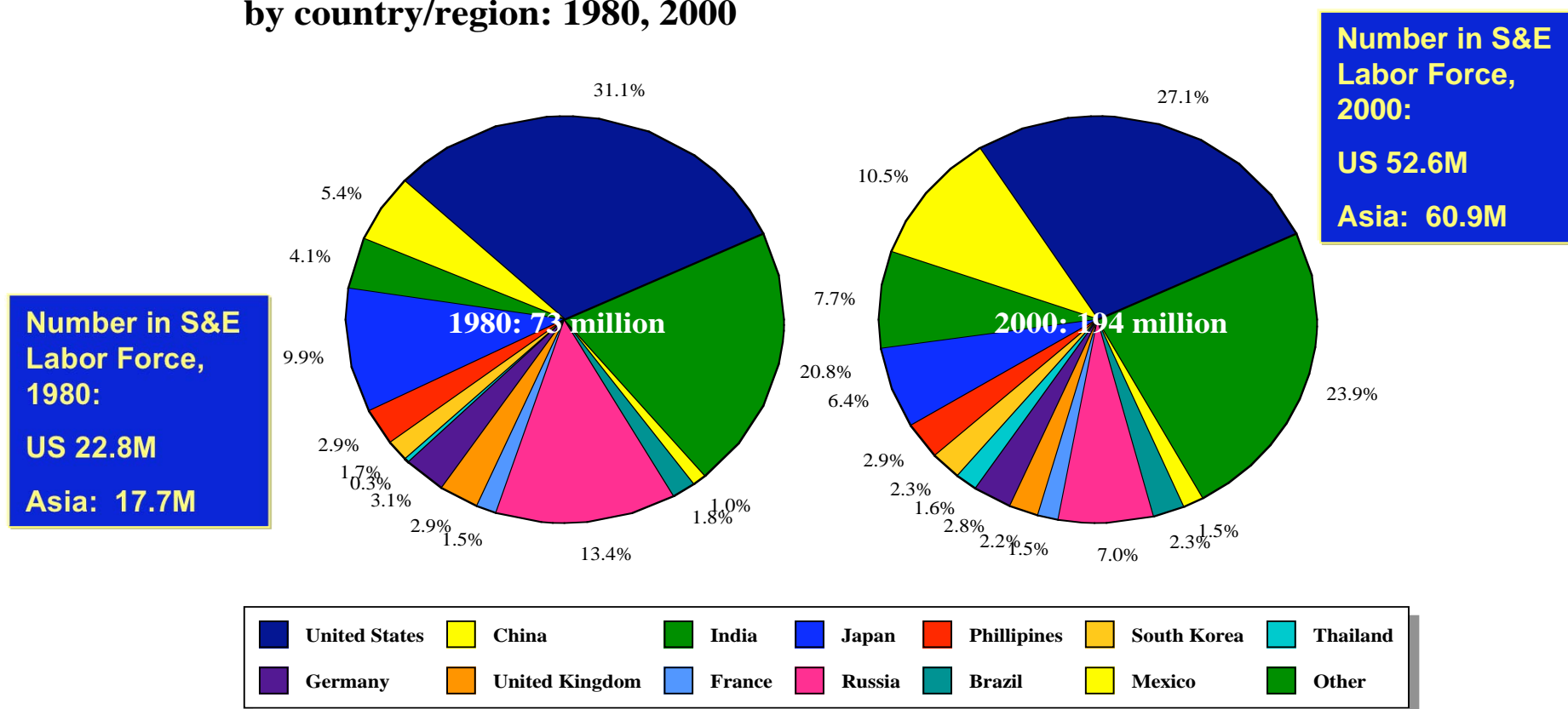
Figure 1. Estimated worldwide R&D expenditures: 1990-2003

Legend:
- United States ($115B, 1994-2003)
- EU ($82B)
- OECD ($272B)
- OECD + nonmembers ($374B)

Rest of World growth ~3x US growth

Y-axis: Billions of dollars (0, 200, 400, 600, 800, 1000)
X-axis: 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2004

NOTE: Billions of current dollars converted with purchasing power parities.
EU data since 1998 include 10 new member countries.
SOURCE: OECD, Main Science and Technology Indicators database, November 2004

Growth of Educated Asian Population

International S&E labor force data can only be approximated.

### Figure 20. Population 15 years and older with tertiary education, by country/region: 1980, 2000

Number in S&E Labor Force, 2000:

US 52.6M

Asia: 60.9M

Number in S&E Labor Force, 1980:

US 22.8M

Asia: 17.7M

1980: 73 million

- 31.1%
- 5.4%
- 4.1%
- 9.9%
- 2.9%
- 1.7%
- 0.3%
- 3.1%
- 2.9%
- 1.5%
- 13.4%
- 1.8%
- 1.0%

2000: 194 million

- 27.1%
- 10.5%
- 7.7%
- 20.8%
- 6.4%
- 2.9%
- 2.3%
- 1.6%
- 2.8%
- 2.2%
- 1.5%
- 7.0%
- 2.3%
- 1.5%
- 23.9%

Color	Country
United States	China	India	Japan	Phillipines	South Korea	Thailand
Germany	United Kingdom	France	Russia	Brazil	Mexico	Other

SOURCE: Adapted from R.J. Barrow and and J. Lee, Center for International Development: International Data on Educational Attainment, 2000

"Disruptive" Commercial Technologies

- Fundamentally can have global impact & change the balance and approach to force expression

- Drives and fuels the need for & new innovative concepts

- Includes how new capabilities are built on emerging technology

- Appearing increasingly from the global commercial marketplace
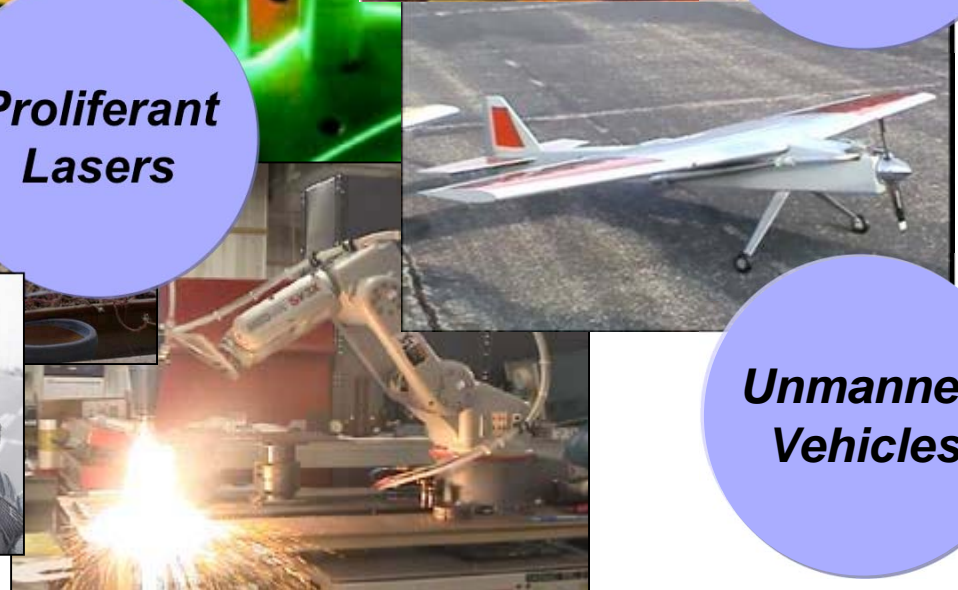
Genetic Engineering
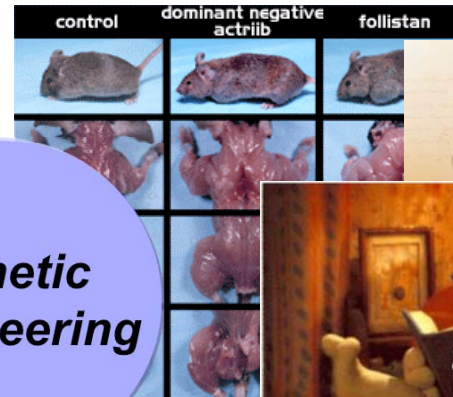
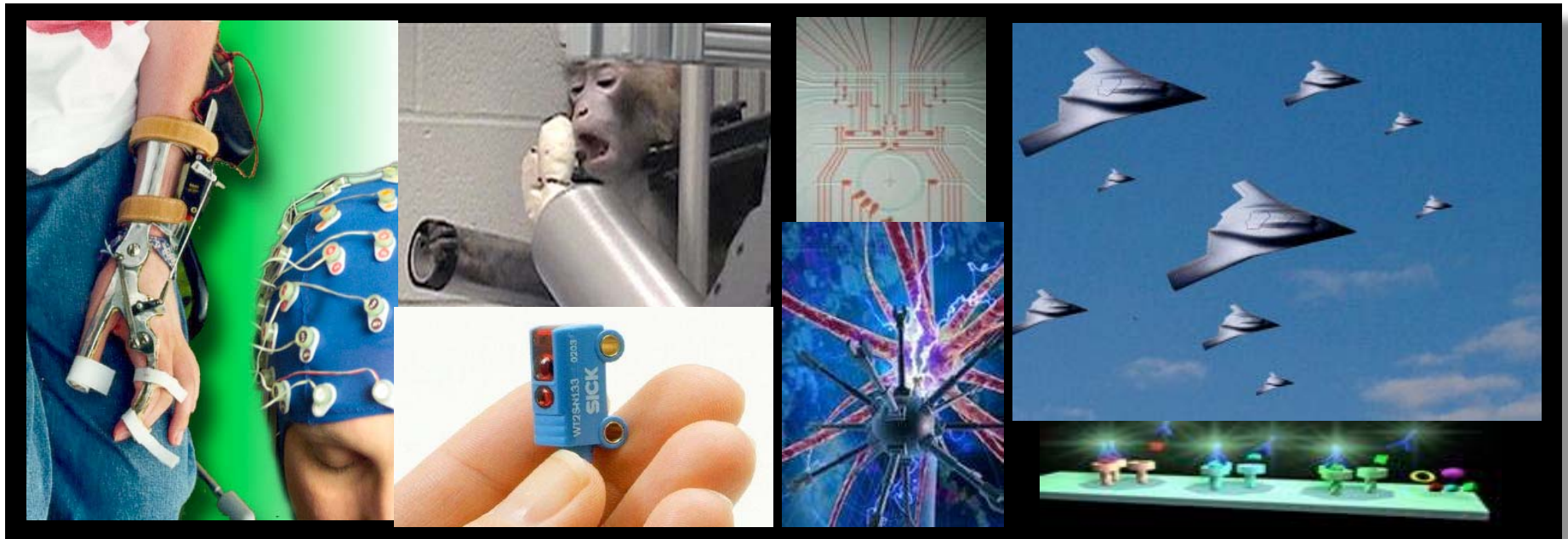*Future Processors*

Proliferant Lasers

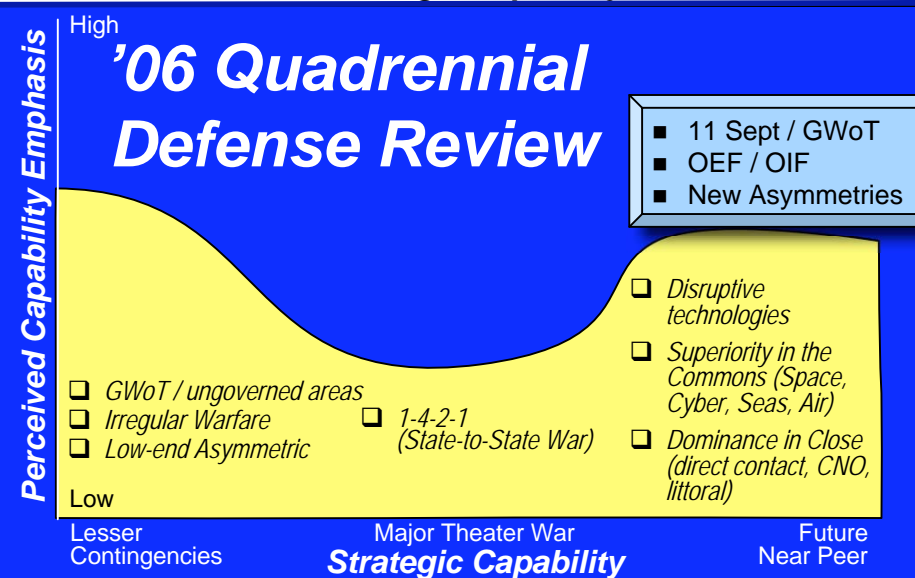*Wireless Devices*
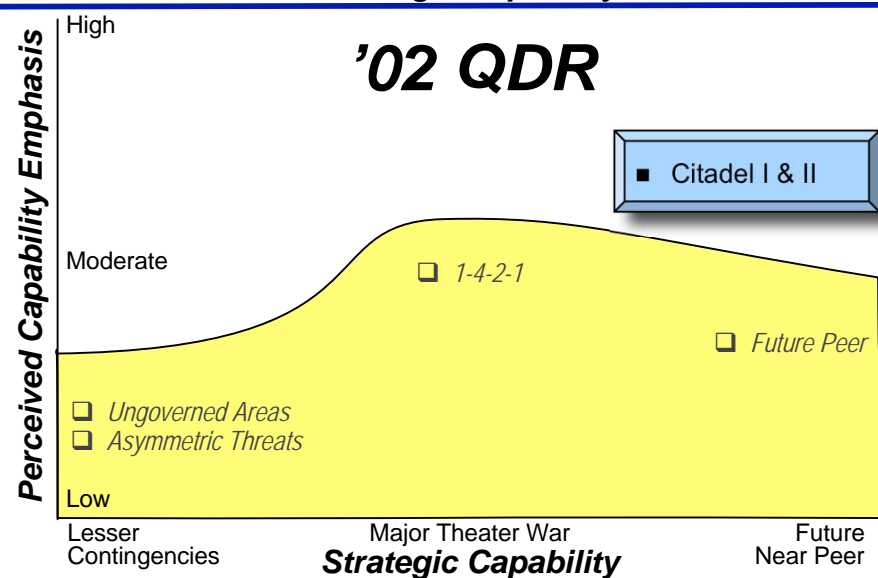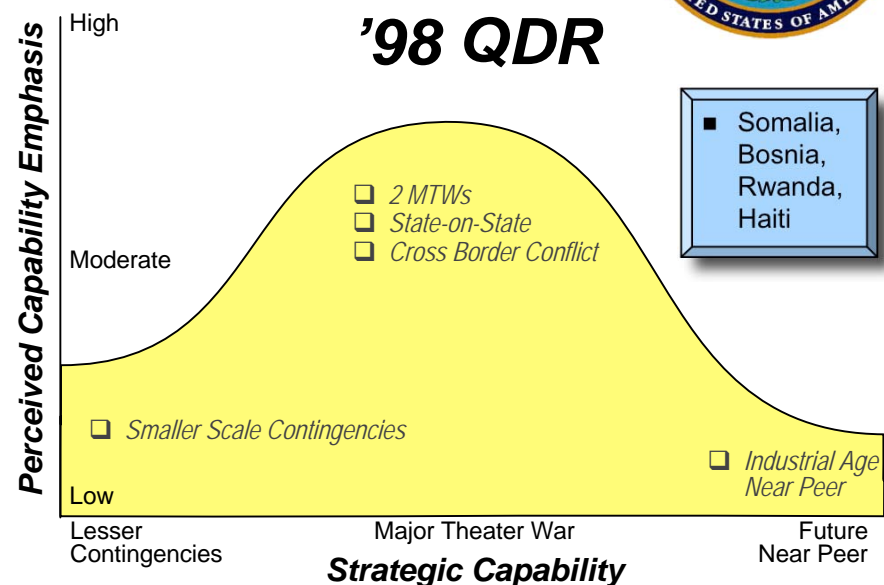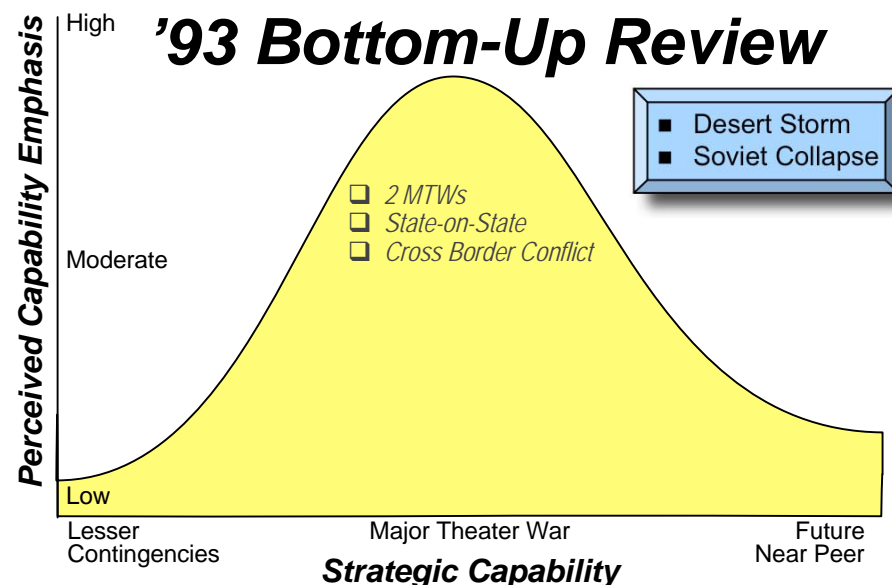
Unmanned Vehicles

Implications

- Greater base of technology development, more agility than previous

- Probability of technology surprise – rapidly increasing

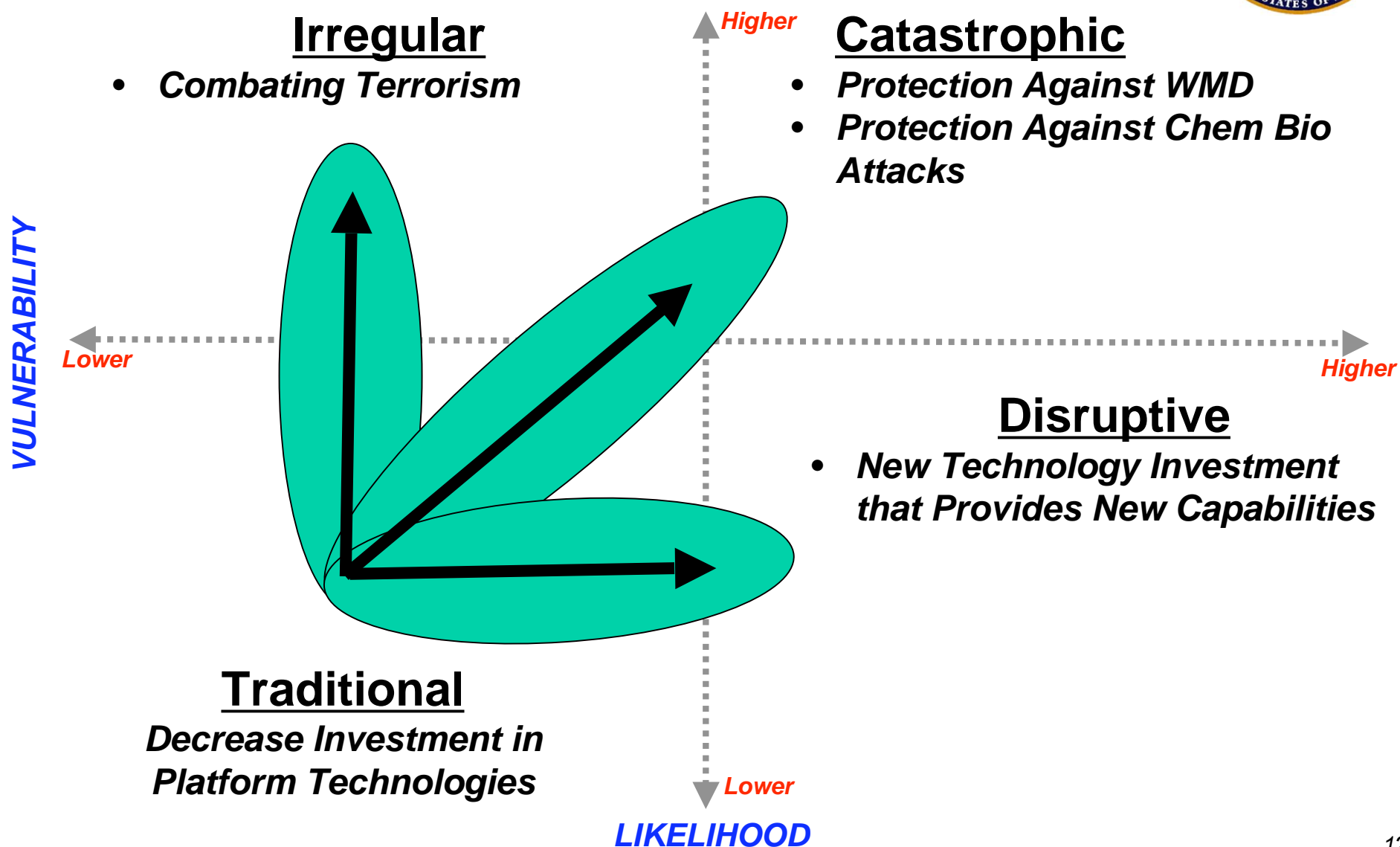- Technology increasingly hybrid, commercial/military

Need Enhanced Technology Scouting and Investment

Decade of Strategic Evolution

'93 Bottom-Up Review

Perceived Capability Emphasis (High / Moderate / Low)

- Desert Storm
- Soviet Collapse

- 2 MTWs
- State-on-State
- Cross Border Conflict

Strategic Capability
Lesser Contingencies — Major Theater War — Future Near Peer

'98 QDR

Perceived Capability Emphasis (High / Moderate / Low)

- Somalia, Bosnia, Rwanda, Haiti

- 2 MTWs
- State-on-State
- Cross Border Conflict

- Smaller Scale Contingencies

- Industrial Age Near Peer

Strategic Capability
Lesser Contingencies — Major Theater War — Future Near Peer

'02 QDR

Perceived Capability Emphasis (High / Moderate / Low)

- Citadel I & II

- 1-4-2-1

- Future Peer

- Ungoverned Areas
- Asymmetric Threats

Strategic Capability
Lesser Contingencies — Major Theater War — Future Near Peer

'06 Quadrennial Defense Review

Perceived Capability Emphasis (High / Moderate / Low)

- 11 Sept / GWoT
- OEF / OIF
- New Asymmetries

- GWoT / ungoverned areas
- Irregular Warfare
- Low-end Asymmetric

- 1-4-2-1 (State-to-State War)

- Disruptive technologies
- Superiority in the Commons (Space, Cyber, Seas, Air)
- Dominance in Close (direct contact, CNO, littoral)

Strategic Capability
Lesser Contingencies — Major Theater War — Future Near Peer

National Defense Strategy
Drives Investment Strategy

Irregular
- *Combating Terrorism*

Catastrophic
- *Protection Against WMD*
- *Protection Against Chem Bio Attacks*

Disruptive
- *New Technology Investment that Provides New Capabilities*

Traditional
Decrease Investment in Platform Technologies

Higher

Lower

Higher

Lower

VULNERABILITY

LIKELIHOOD

Science and Technology
Enabling Technology Priorities

Technology focus areas:

- Biometrics and Biological exploitation
- Information technology and applications
- Persistent Surveillance Technology
- Networks and Communication
- Human, Social, Cultural, and Behavioral Modeling
- Language
- Cognitive Enhancement
- Directed Energy
- Autonomous systems
- Hyperspectral sensors
- Nanotechnology
- Advanced Materials
- Energy and Power
- Affordability
- Combating Weapons of Mass Destruction Technologies
- Energetic Materials

In Blue -- Areas with Substantial High-Performance Computer Needs

Big Moves Last Three Budgets

FY2008 (~$1.5B across the FYDP)

Biometrics Research (~$70M)
Human Cultural Social
    Behavioral Modeling (~$210M)
Networked Communications (~$190M)
Persistent Surveillance (~$100M)
Energy Research (~$150M)
Clandestine TT&L (~$300M)
Armor Technology (~$200M)
Manufacturing S&T (~$100M)

FY2009 (~$2B across the FYDP)

Basic Research (~$1.5B)
Increased Protection Demonstrations
    for Dismounted Troops (~$200M)
Novel LO/CLO Technologies (~$150M)
Cyber Protection (~$100M)
Anti-tamper Technology
    (~$10M – to be completed in FY10)

FY2010 (~$2.2B across the FYDP)

Medical S&T (Wounded Warrior) (~$2.5B total; about $1B in S&T, the rest in Defense Health Protection)
Large Data Handling (ISR Capability) (~$100M)
Expanded Cyber Protection and Anti-Tamper (~$450M)
High Temperature Materials (~$70M)
Stand-off Detection of Fissile Materials (~$300)
High Performance Computing (~$100M)
Minerva (Sociology Research) (~$100M)

Key
Joint Programs
Multiple Executors
Army
Navy
Air Force

DoD HPC Modernization Program

DoD Supercomputing Resource Centers

ARSC
AFRL★
ARL★
MHPCC
ERDC★
NAVY★

Affiliated Resource Centers
AFRL-RY   NRL   SMDC

Networking
Defense Research & Engineering Network

Outside US:
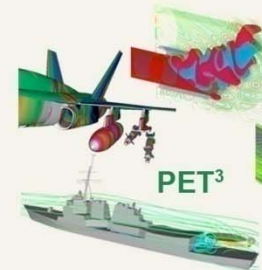United Kingdom LJCS
Guaynabo, PR

Program Motivation

Provide the DoD research, development and test and evaluation (RDT&E) community the world-class commercial, high-end, high-performance computational capability they need to rapidly apply advanced technology to develop superior Warfighting capabilities.
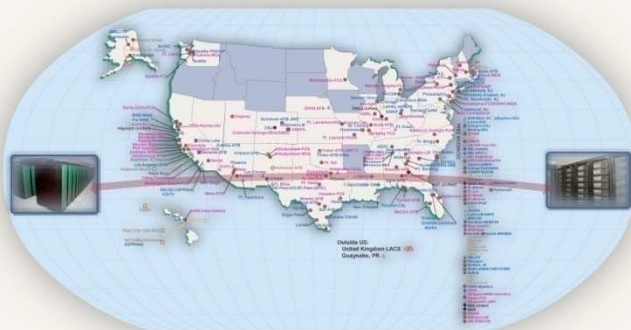
Approach

Develop and subsequently sustain complete and balanced HPC environments based on user requirements to solve the most demanding problems.

Software Applications Support
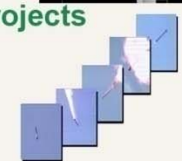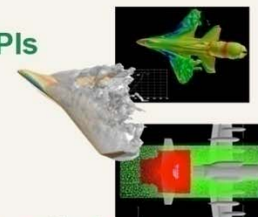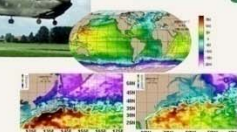
Institutes/Portfolios

Education & Outreach

CREATE

PET^3

SPI

ATSPI

Resource Management
Requirements & Allocations

DHPIs

Challenge Projects

Solving the hard problems . . .

DoD HPCMP Activities

- Since 2006, the DoD HPCMP has completed three Return on Investment (ROI) Studies
  - Armor, Anti-Armor Portfolio
  - Climate/Weather/Ocean (CWO)
  - Air Vehicles
- Develop and implement validated and repeatable processes
- When appropriate, involved the Operational Warfighter

Directly shaped success of Secretary Gates' #1 Acquisition Program: Mine Resistant Ambush Protected (MRAP) Vehicles

Interim Frag Kit 6 (IFK6) for UAH:
From HPC to Iraq in < 4 Months

- HPC assets provided complete conceptualization of candidate designs

- HPC used to examine mechanisms, screen design options, and down select final armor configuration.

- Verification testing proved HPC design methodology and validated accelerated fielding by reliance on a closely coupled HPC/experimental approach.

- IFK-6 based designs developed for many other platforms including RCVs & MRAPs

Fielded in Iraq

Significant Quantities of MRAPs Fielded in < 2 years

IFK6: Starting Point

- IFK6 supported MRAP research

- Multiple alternative technologies examined through coupled HPC & Experimentation

- HPC used to examine technologies and system designs to optimize solutions.

- Verification testing proved HPC design methodology and validated accelerated fielding by reliance on a closely coupled HPC/experimental approach.

Three Principal Objectives
-DoD Strategic Imperatives-

"As changes in this century's threat environment create strategic challenges – irregular warfare, weapons of mass destruction, disruptive technologies – this request places greater emphasis on basic research, which in recent years has not kept pace with other parts of the budget."

Secretary of Defense, Budget Recommendation Statement, Arlington, VA, April 6, 2009

1. Take care of our people
2. Develop the right capabilities for today and tomorrow
   - Persistent surveillance
   - Cyberspace operations/protection
   - Combating weapons of mass destruction
   - Irregular warfare
3. Reform the Procurement, Acquisition, and Contracting processes

SecDef Strategic Imperative
- Objective 1: Take care of our people -

- **Personnel & Platform Protection**

- **Advanced Medical Research**

- **Education**

SecDef Strategic Imperative
Objective 2: Develop the right capabilities for today & tomorrow -

- Combating Weapons of Mass Destruction
- Advanced Tagging, Tracking, & Locating
- Cyberspace Operation/Protection Technologies
- Battlespace Awareness
- Energy & Power
- Unmanned Vehicles
- Advanced Electronics
- Advanced Materials
- Processing Large Data Sets
- Intelligence, Surveillance & Reconnaissance
- Human, Social, Cultural, Behavior Modeling
- Software Development

SecDef Strategic Imperative
- Objective 3: Reform the Procurement, Acquisition & Contracting processes -

Four new "organizations":

- **Director of Cost Assessment and Program Evaluation (CAPE)**
  - **Formerly PA&E (Program Assessment and Evaluation)**
- **Director of Systems Engineering**
  - **Formerly SSE**
  - **Consolidate all pre-MS B efforts within DDRE**
- **Director of Developmental Test**
  - **Independent entity**
- **"Senior official" for Performance Assessment and Root Cause Analysis**
  - **Consolidate efforts with Program Systems Review (PSR)**
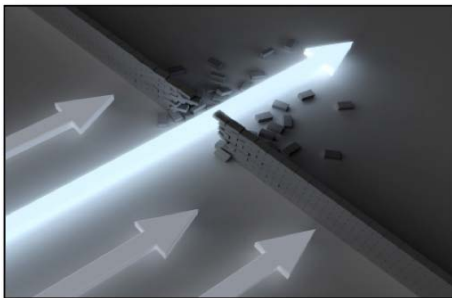
Acquisition Reform Act - 2009
Responsibilities

- Technology Maturity Assessments (TMA's)
  - Periodic reviews of all MDAP's
  - Annual congressional report
  - Assess technology maturity and *integration risk (new)*
- Systems Engineering
  - Assess SEP's and development planning for all MDAPs
  - Oversee SE workforce and certification process
  - Review Service SE organizations
- Developmental Test and Evaluation
  - Assess DT&E plans for all MDAPs
  - Review Service DT&E organizations

The Challenge & Opportunity

The Challenge:

> "Unfortunately, our assessments do not show appreciable improvement in the acquisition of major weapon systems. Rather, programs are experiencing recurring problems with cost overruns, missed deadlines, and performance shortfalls." page 1, GAO-06-391, similar concern page 70 QDR

The Opportunity:

Strengthen the engineering and test efforts by injecting computational research & engineering for acquisition tools & environments (CREATE)

A

B

C

IOC

FOC

CONCEPT REFINEMENT	TECHNOLOGY DEVELOPMENT	SYSTEM DEVELOPMENT & DEMONSTRATION	PRODUCTION & DEPLOYMENT	OPERATIONS & SUPPORT
Concept Decision		Design Readiness Review	FRP Decision Review	
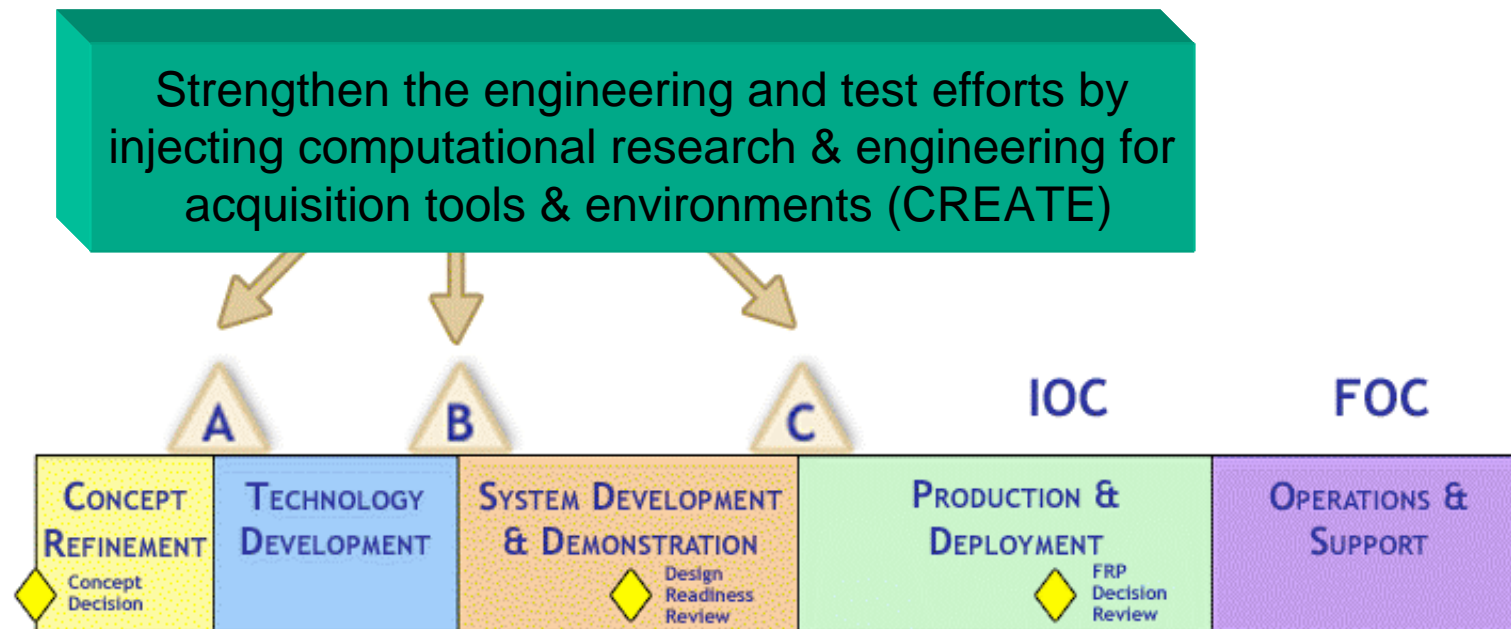
Computational Research and Engineering Acquisition Tools and Environments (CREATE)

- CREATE will insert modern engineering practices and advanced technology into the early phases of the acquisition process to make it more effective.

- CREATE will strengthen the weapon systems technology development, engineering design and test & evaluation portions of the acquisition process yielding more highly optimized designs faster, allowing better and faster tests resulting in more capable weapon systems that cost less.
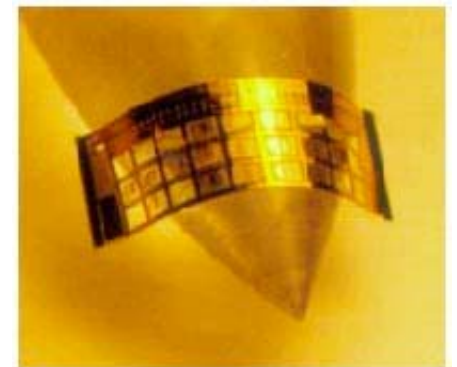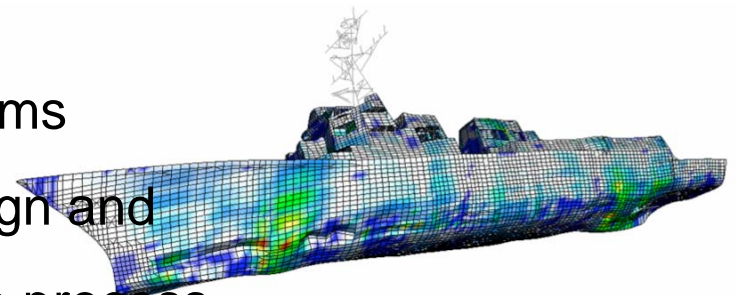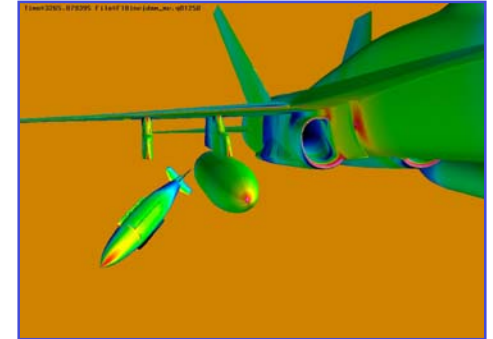
Why does the DoD need CREATE?

- Top-down direction: The QDR states (pp. 16, 67-71, A-6) that a more effective, and agile and flexible acquisition process is a high priority.

  - Many weapons systems are over-budget, late, and don't meet performance goals (e.g. GAO-06-391(March 2006)).

  - Lengthy and rigid acquisition process degrades ability to address rapidly changing irregular, catastrophic and disruptive threats.

- Many of these problems can be traced to an ineffective design process.

- Our present design tools are inadequate to produce an integrated design with few flaws.

CREATE Tools
Delivered Incrementally (over 10 years)
in a resource-sharing environment

Mesh generation

Computational Math

Coordination and Oversight

Data Analysis and Visualization

Collaboration tools

Aircraft Design Tool

- Early capability:
  - Optimize aerodynamic performance
  - Preliminary analysis of stability and control
- Mid-term capability
  - Rotorcraft design
  - Full aircraft analysis
- Full-term capability
  - Address design optimization, analysis and testing including dynamic aero-elastic effects and capability for hypersonics
  - Assess interoperability with C4ISR

Naval Ship Design Tool

- Early capability:
  - Initial mesh generation
  - Initial live fire test simulations
  - Initial ocean hydrodynamic capability
- Mid-Term capability
  - Higher fidelity live fire test simulation
  - Hydrodynamic capability with high fidelity turbulence models
- Full-term capability
  - Validated live fire test simulations
  - Ocean hydrodynamics integrated with structural mechanics and shock hydrodynamics

RF Sensor and C4ISR Antenna Design Tool

- Early capability
  - Enhanced and coupled versions of present antenna design tools
- Mid-term capability
  - Modernized code with initial capability to design in-situ conformal antennas, integrated feeds, assess wideband performance,..
- Full-term capability
  - Full validated in-situ design capability with enhancements

VISION: To develop technology to defeat any adversary on any battlefield

Any Battlefield includes physical, cyber, space, undersea, etc

Transformation

QUESTIONS?